Hindi vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the S.Y.B.Sc.

Program: B.Sc. Statistics

Program Code: RJSUSTA

Choice based Credit System (CBCS)

With effect from the academic year 2018-19

S.Y.B.Sc. STATISTICS Syllabus

Credit Based and Grading System

To be implemented from the Academic year 2018-2019

SEMESTER III

Theory

Course Code	Unit	Topics	Credits	L / Week
RJSUSTA301	I	Univariate Random Variables. (Discrete and Continuous)	2	1
	II	Standard Discrete Probability Distributions.		1
	III	Bivariate Probability Distributions.		1
RJSUSTA302	I	Concepts of Sampling and Simple Random Sampling.	2	1
	II	Stratified Sampling.		1
	III	Ratio and Regression Estimation.		1
RJSUSTA303	I	Linear Programming Problem (L.P.P)	2	1
	II	Transportation problem		1
	III	Assignment Problem		1
RJSUSTAP301	Practicals based on RJSUSTA301		1	3
RJSUSTAP302	Practicals based on RJSUSTA302		1	3
RJSUSTAP303	Practicals based on RJSUSTA303		1	3

Learning Objectives:

- To understand the patterns in the of data of large populations
- To obtain the central location and dispersion of the data
- To know the relationship between various distributions

Course Code	Title	Credits
RJSUSTA301	**PROBABILITY DISTRIBUTIONS**	**2 Credits (45 lectures)**
Unit I : Univariate Random Variables (Discrete and Continuous) Moment Generating Function(M.G.F.): Definition Properties: - Effect of change of origin and scale, - M.G.F of sum of two independent random variables X and Y , - Extension of this property for n independent random variables and for n i.i.d. random variables. All above properties with proof, - Uniqueness Property without proof. - Raw moments using M.G.F: using expansion method and using derivative method. Cumulant generating Function(C.G.F.): Definition Properties: - Effect of change of origin and scale , - Additive Property of C.G.F. Both properties with proof. Obtaining Cumulants using C..G.F. Derivation of relationship between moments and cumulants upto order four. Characteristic Function- Definition and properties (without Proof) Examples of obtaining raw moments and central moments up to order four using M.G.F. and C.G.F. for continuous and discrete distributions. Degenerate Distribution (One point distribution) P (X = c) = 1 Mean, Variance. Discrete Uniform distribution Mean, Variance, coefficient of skewness using m.g.f. Bernoulli distribution Mean, Variance, coefficient of skewness using m.g.f. Binomial distribution : Mean, Variance, Measures of skewness and Kurtosis based on moments using		**15 Lectures**

M.G.F.and C.G.F. , Nature of probability distribution with change in the value of parameter , Mode, Additive property , If X follows Binomial, then to find distribution of n - X. Recurrence relation for moments with proof: $\mu'_{r+1} = np\,\mu'_r + pq\,\frac{d}{dp}\,\mu'_r$ $\mu_{r+1} = pq\,[\,nr\,\mu_r + \frac{d}{dp}\,\mu_r$ Fitting of Binomial Distribution. Relation between Bernoulli and Binomial using m.g.f.	
Unit II : Standard Discrete Probability Distributions Poisson distribution Mean, Variance, Measures of skewness and Kurtosis based on moments using M.G.F.and C.G.F. , Nature of probability distribution with change in the value of parameter, Mode, Additive property. Recurrence relation for moments with proof for μ'_{r+1} & μ_{r+1} If X and Y are two independent Poisson variables Conditional distribution of X given X+Y (with proof). Poisson distribution as limiting distribution of Binomial (with proof) Real life examples of Binomial, Poisson distribution. Fitting of Poisson Distribution. Geometric Distribution Definition in terms of No. of failures and No. of trials. Mean, Variance. M.G.F., Mean and Variance using M.G.F., C.G.F., Mean, Variance, μ_3, μ_4 using C.G.F. Coefficients of skewness and Kurtosis and Nature of probability distribution with change in the value of parameter. Property of Lack of Memory (with proof) If X and Y are two i.i.d. Geometric variables; Conditional distribution of X given X+Y(with proof) Distribution of k i.i.d. Geometric variables. Negative Binomial Distribution Definition, Mean, Variance. M.G.F., Mean and Variance using M.G.F.. C.G.F., Mean, Variance, μ_3, μ_4 using C.G.F., Coefficients of skewness and Kurtosis and Nature of probability distribution with change in the value of parameter. Recurrence relation for probabilities, Fitting of distribution Limiting distribution of Negative Binomial distribution (with proof) Hyper-geometric distribution Definition, Mean, Variance, Limiting distribution of Hyper-geometric distribution. If X and Y are two independent Binomial variables Conditional distribution of X given X+Y Truncated distribution Definition: Truncated Binomial and Truncated Poisson Distribution: (truncated at 0) probability mass function, mean and variance.	**15 Lectures**

Real life situations of Geometric, Negative Binomial, Hyper-geometric distributions	
Unit III: Bivariate Probability Distributions Two dimensional Discrete random variables -Joint Probability mass function and its properties. -Distribution function of (X, Y)and its properties. -Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables -Marginal and conditional probability distributions -Conditional expectation, conditional variance Continuous bivariate random variables -Joint Probability density function and its properties -Distribution function of (X, Y)and its properties -Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables -Marginal and conditional probability distributions -Conditional expectation, conditional variance - Regression Function.	**15 Lectures**

REFERENCES

1) Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.
2) Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
3) Probability and Statistical Inference: R.V.Hogg, E. A.Tannis, Third Edition; Collier McMillan Publishers.
4) John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5) Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
6) Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
7) Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
8) Statistical Methods: An Introductory Text: J. Medhi; Second edition; Wiley Eastern Ltd.
9) An outline of statistical theory Vol. I: A.M Goon, M. K. Gupta, B. Das Gupta: Third Edition: The World Press Pvt. Ltd.

Learning Objectives:

- To understand various sampling techniques
- To apply these techniques in real life situation
- Comparison of sampling techniques

Course Code	Title	Credits
RJSUSTA302	**THEORY OF SAMPLING**	**2 Credits (45 lectures)**
Unit I : Concepts of Sampling and Simple Random Sampling. a) Concept of sampling : Population, Population unit, Sample, Sample unit, Parameter, Statistic, Estimator, Bias, Unbiased Estimator, Mean square error & Standard error. Census Survey, Sample Survey. Steps in conducting sample survey with examples on designing appropriate Questionnaire. Concepts of Sampling and Non-sampling errors. NSSO, CSO and their functions. Concepts and methods of Probability and Non-Probability Sampling. b) Simple Random Sampling (SRS) : Definition, Sampling with & without replacement (WR/WOR). Lottery method & use of Random numbers to select simple random sample. Estimation of population mean & total. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators.(WR/WOR). Estimation of population proportion. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators (WR/WOR). Estimation of sample size based on a desired accuracy in case of SRS for variables & attributes (WR/WOR).		**15 Lectures**
Unit II: Stratified Sampling. a) Concepts : Need for Stratification of population with suitable examples. Definition of Stratified Sample. Advantages of Stratified Sampling. b) Stratified Random Sampling : Estimation of population Mean and Total in case of Stratified Random Sampling (WOR within each strata). Expectation and Variance of the unbiased estimators, Unbiased estimators of variances of these estimators. Proportional allocation, Optimum allocation with and without varying costs. Comparison of Simple Random Sampling, Stratified Random Sampling using Proportional allocation and Neyman allocation.		**15 Lectures**

Unit III: Ratio and Regression Estimation	**15 Lectures**
a) Ratio & Regression Estimation Method assuming SRSWOR Ratio Estimators for population Ratio, Mean and Total. Expectation & MSE of the Estimators. Estimators of MSE. Uses of Ratio Estimator. Regression Estimators for population Mean and Total. Expectation and Variance of the Estimators assuming known value of regression coefficient 'b'. Estimation of 'b'. Resulting variance of the estimators. Uses of regression Estimator. Comparison of Ratio, Regression & mean per unit estimators. b) Introduction to different methods of sampling. Introduction to Systematic sampling, Cluster sampling and Two stage sampling with suitable illustrations.	

REFERENCES :

1. Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley(1978)
2. Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
3. Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968).
4. Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V. Sukhatme; 3rd Edition; Iowa State University Press (1984).
5. Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
6. Theory and Analysis of Sample Survey Designs: Daroga Singh, F.S.Chaudhary, Wiley Eastern Ltd. (1986).
7. Sampling Theory and Methods: S. Sampath, Second Edition (2005),Narosa.
8. Theory and Methods of Survey Sampling: Parimal Mukhopadhyay, (1998), Prentice Hall Of India Pvt. Ltd.

Learning Objectives:

- To learn mathematical formulation of real life situations.
- To study methods to solve the formulated problems.
- T o learn the application of Operations research in industry.

Course Code	Title	Credits
RJSUSTA303	**OPERATION REASERCH-1**	**2 Credits (45 lectures)**
Unit I: Linear Programming Problem (L.P.P) Mathematical Formulation : Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal Solution. Graphical Solution for problems with two variables. Simplex method of solving problem with two or more variables. Big M method. Concept of duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and dual. Economic interpretation of Dual.		**15 Lectures**
Unit II: Transportation problem Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. Variants in Transportation Problem: Unbalanced, Maximization type.		**15 Lectures**
Unit III: Assignment Problem Concept. Mathematical Formulation. Solution by: Complete Enumeration Method and Hungarian method. Variants in Assignment Problem: Unbalanced, Maximization type. Travelling Salesman Problem. Sequencing : Processing n Jobs through 2 and 3 Machines & 2 Jobs through m Machines.		**15 Lectures**

REFERENCES

1. Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons.
2. Schaum Series book in O.R. Richard Broson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
3. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
4. Mathematical Models in Operations Research : J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
5. Principles of Operations Research with Applications to Management Decisions: Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.
6. Operations Research: S D Sharma 11th edition, Kedar Nath Ram Nath & Company.
7. Operations Research: H. A. Taha.6th edition, Prentice Hall of India.
8. Quantitative Techniques For Managerial Decisions: J.K.Sharma , (2001), MacMillan India Ltd.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-III

Sr. No.	Course Code: **RJSUSTAP301**
1	Moment Generating Function, Moments.
2	Cumulant generating Function, Cumulants, Characteristic function.
3	Standard Discrete Distributions.
4	Fitting Standard Discrete Distributions.
5	Bivariate Probability Distributions, Marginal & Conditional distributions, Conditional Mean, Conditional Variance, Correlation.
6	Transformation of discrete & continuous random variables.

Sr. No.	Course Code: **RJSUSTAP302**
1	Designing of Questionnaire.
2	Simple Random Sampling for Variables.
3	Simple Random Sampling for Attributes.
4	Estimation of Sample Size in Simple Random Sampling
5	Stratified Random Sampling.
6	Ratio and Regression Estimation.

Sr. No.	Course Code: **RJSUSTAP303**
1	Formulation and Graphical Solution of L.P.P.
2	Simplex Method
3	Duality
4	Transportation Problems
5	Assignment Problems
6	Sequencing Problems

SEMESTER –IV

Theory

Course Code	Unit	Topics	Credits	L / Week
RJSUSTA401	I	Standard Continuous Probability Distributions	2	1
	II	Normal Distribution		1
	III	Exact Sampling Distributions		1
RJSUSTA402	I	Analysis Of Variance	2	1
	II	Design of Experiments		1
	III	Factorial Experiment.		1
RJSUSTA403	I	CPM – PERT	2	1
	II	Game Theory		1
	III	Decision Theory		1
RJSUSTAP401	Practicals based on RJSUSTA401		1	3
RJSUSTAP402	Practicals based on RJSUSTA402		1	3
RJSUSTAP403	Practicals based on RJSUSTA403		1	3

Learning Objectives:

- To understand the patterns in the data of large populations.
- To obtain the central location and dispersion of the data.
- To know the relationship between various distributions.

Course Code	Title	Credits
RJSUSTA401	**PROBABILITY AND SAMPLING DISTRIBUTIONS**	**2 Credits (45 lectures)**

Unit I: Standard Continuous Probability Distributions — **15 Lectures**

Rectangular or Continuous Uniform over (a,b). Mean, Median Standard deviation, C.D.F.,M.G.F., Mean ,variance, μ_3 using M.G.F., skewness of distribution

For X following U (0,1), distribution of i) $\frac{X}{1+X}$, ii) $\frac{X}{1-X}$

Triangular distribution over(a,b) with peak at c

-M.G.F.

Exponential Distribution (Single parameter)

Definition, M.G.F.,C.G.F. raw moments and central moments upto order four using M.G.F..and C.G.F.

- Measures of Skewness and Kurtosis ,Nature of Probability curve
- Median and Quartiles,

-Forgetfulness Property with proof and examples based on it.

-Distribution of ratio of two i.i.d. Exponential variables.

-Distribution of X+Y and $\frac{X}{X+Y}$,for two independent Exponential variables X and Y with mean(1). (All with proof.)

Cauchy (with location and scale parameter)

-Properties without proof

Gamma (with scale and shape parameter)

Expression for r th raw moment

Mean, Mode & Standard deviation. M.G.F., Additive property, C.G.F.. raw moments and central moments upto order four using M.G.F.. and C.G.F.

Coefficient of skewness and kurtosis and nature of probability curve.

Distribution of sum of independent Exponential variables,

Beta Distribution: Type I & Type II

Expression for r th raw moment, Mean, Mode Standard deviation.

If a r.v. X follows Beta of type 1, distribution of 1- X

If a r.v. X follows Beta of type 2, distribution of i) $\frac{1}{1+X}$, ii)$\frac{X}{1+X}$ (with proof).

For two independent Gamma variables X and Y with parameters m and n respectively, distribution of U = $\frac{X}{Y}$ and V= $\frac{X}{X+Y}$ (with proof)

Unit II: Normal Distribution Definition, Derivation of Mean, Median, Mode, Standard deviation, M.G.F. , C,G,F., Moments & Cumulants (up to fourth order). skewness & kurtosis, Nature of Normal curve, Mean absolute deviation. Properties of Normal Distribution. Expression for even order central moments and to show that odd order central moments zero. Distribution of Standard Normal Variable Distribution of linear function of independent Normal variables (i) aX, (ii) X+b, (iii) aX+bY in particular X+Y and X-Y, (iv) aX+bY+c (all with proof.) Fitting of Normal Distribution. Central Limit theorem for i.i.d. random variables.(only statement) Log Normal Distribution: Derivation of mean & variance.	**15 Lectures**
Unit III: Exact Sampling Distributions Chi-Square Distribution: Derivation of p.d.f. Mean, Mode & Standard deviation. M.G.F.,C.G.F., Measures of skewness and kurtosis, Additive property Distribution of ratio two independent Chi-square variables Distribution of $\frac{X}{X+Y}$ if X and Y two independent Chi-square variables All with proof Distribution of the sum of squares of independent Standard Normal variables. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution (without proof). Applications of Chi-Square: Development of decision criterion with test procedures of (i)Test of significance for specified value of variance of a Normal population (ii)Test for goodness of fit, Test Procedure for independence of attributes. (i) rxc contingency table, (ii) 2x2 contingency table, Derivation of test statistic, Yates'correction with proof Derivation of Confidence interval for the variance of a Normal population when (i) mean is known, (ii) mean is unknown.	**15 Lectures**

Student t-distribution: Derivation of p.d.f. **,** Mean, variance, r^{th} order raw moment, Mean Deviation, Measures of skewness and Kurtosis and Additive property. Limiting distribution of t distribution with proof. Applications of t distribution: Development of decision criterion with test procedure of Test of significance for specified value of mean of Normal population. Test procedure of test of significance for difference between means of (i) two independent Normal populations with equal variances (ii) Dependent samples (Paired t test) Derivation of Confidence intervals for (i) Mean of Normal population, (ii) difference between means of two independent Normal populations having the same variance. Snedecor's F-distribution: Derivation of p.d.f. **,** Expression for r^{th} raw moment, Mean, Mode & Standard deviation Distribution of Reciprocal of F variable with proof. Applications of F distribution: Test procedure for testing equality of variances of two independent Normal populations i. Mean is known ii. Mean is unknown Derivation of confidence interval for ratio of variances of two independent Normal populations.	

REFERENCES

1. Introduction to the theory of statistics: A M Mood, F.A. Graybill, D C Boyes; Third Edition; McGraw-Hill Book Company.
2. Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
3. Probability and Statistical Inference: R.V.Hogg, E. A.Tannis, Third Edition; Collier McMillan Publishers.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
6. Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
7. Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
8. Statistical Methods- An Introductory Text: J. Medhi; Second edition; Wiley Eastern Ltd.
9. An Outline of Statistical Theory Vol. 1: A.M. Goon, M.K. Gupta, B. DasGupta: Third Edition; The World Press Pvt. Ltd.

Learning Objectives:

- T o introduce and apply the techniques and methodology available for designing and analysis of experiment.
- To emphasize the need for sound and unambiguous interpretation of experimentation.

Course Code	Title	Credits
RJSUSTA402	**ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS**	**2 Credits (45 lectures)**
Unit I: Analysis Of Variance Introduction, Uses, Cochran's Theorem (Statement only). One way classification with equal & unequal observations per class, Two way classification with one observation per cell. Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard Error and Confidence limits for elementary treatment contrasts.		**15 Lectures**
Unit II: Design Of Experiments a) Introduction: Concepts of Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. Principles of Design of Experiments: Replication, Randomization & Local Control. Efficiency of design D1 with respect to design D2. Choice of size, shape of plots and blocks in agricultural & non agricultural experiments. b) Completely Randomized Design (CRD) and Randomized Block Design (RBD) Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for		**15 Lectures**

elementary treatment contrasts. Efficiency of RBD relative to CRD.	
Unit III: Factorial Experiments a) Latin Square Design Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of the design relative to RBD, CRD. Missing plot technique for one missing observation in case of CRD, RBD and LSD. b)Factorial Experiments Definition, Purpose & Advantages. 2^2, 2^3 Experiments. Calculation of Main & interaction Effects. Definition of contrast and orthogonal contrast, Yates' method. Analysis of 2^2 & 2^3 factorial Experiments.	**15 Lectures**

REFERENCES

1. Experimental Designs: W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.
2. The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
3. Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition;John Wiley & Sons.
4. Design and Analysis of Experiments: M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited;1986.
5. Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
6. Fundamentals of Applied Statistics: S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
7. Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company

Learning Objectives:

- T o learn the application of Operations research in industry.
- To plan and schedule projects.

Course Code	Title	Credits
RJSUSTA403	**OPERATION REASERCH-2**	**2 Credits (45 lectures)**
Unit I: CPM AND PERT Objective and Outline of the techniques. Diagrammatic representation of activities in a project: Gantt Chart and Network Diagram. Slack time and Float times. Determination of Critical path. Probability consideration in project scheduling. Project cost analysis. Updating.		**15 Lectures**
Unit II: Game Theory Definitions of Two persons Zero Sum Game, Saddle Point, Value of the Game, Pure and Mixed strategy, Maximin principle Minimax principle, Optimal solution of two person zero sum games. Dominance property, Derivation of formulae for (2×2) game. Graphical solution of $(2\times n)$ and $(m\times2)$ games, Reduction of game theory to LPP		**15 Lectures**
Unit III: Decision Theory Decision making under uncertainty: Laplace criterion, Maximax (Minimin) criterion, Maximin (Minimax) criterion, Hurwitz α criterion, Minimax Regret criterion. Decision making under risk: Expected Monetary Value criterion, Expected Opportunity Loss criterion, EPPI, EVPI. Bayesian Decision rule for Posterior analysis. Decision tree analysis along with Posterior probabilities.		**15 Lectures**

REFERENCES

1. PERT and CPM, Principles and Applications: Srinath. 2nd edition, East-West Press Pvt. Ltd.
2. Quantitative Techniques For Managerial Decisions: J.K.Sharma, (2001), MacMillan India Ltd.
3. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
4. Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company.
5. Operations Research: Kantiswaroop and Manmohan, Gupta. 12thEdition; S Chand & Sons.
6. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
7. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
8. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman,(1959), John Wiley & Sons.
9. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
10. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
11. Banerjee B. : Operations Research Techniques for management 1st edition, Business Books.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-IV

Sr. No.	Course Code: **RJSUSTAP401**
1	Standard Continuous distribution
2	Normal distribution
3	Central Limit Theorem
4	Chi Square Distribution
5	t Distribution
6	F Distribution

Sr. No.	Course Code: **RJSUSTAP402**
1	Analysis Of Variance- One Way Classification
2	Analysis Of Variance- Two Way Classification
3	Completely Randomized Design
4	Randomized Block Design
5	Latin Square Design
6	Missing Observation in CRD, RBD, and LSD.
7	Factorial Experiment

Sr. No.	Course Code: **RJSUSTAP403**
1	CPM-PERT : 1
2	CPM-PERT : 2
3	CPM-PERT : 3
4	Game Theory
5	Decision Theory : 1
6	Decision Theory : 2

Semester End Examination

Theory: At the end of the semester, examination of two (2) hours duration and sixty (60) marks based on the three units shall be held for each course.

Pattern of **Theory question** paper at the end of the semester for ***each course*** will be as follows:

Total number of questions three, each of twenty marks.

Question one, two and three are based on unit I, unit II and unit III respectively.

Practical : At the end of the semester, examination of two hours duration and 45 marks shall be held for **each course**. Five marks for journal (45+05=50).

Students will attempt five questions out of seven questions, each of nine marks. Each question may contain sub questions.

Internal Examination

The paper pattern of the question paper of IA1 and IA2 will be as follows:

Question one : 5 questions of one mark each, Question two: (a) 1 question of two marks, (b) 1 question of three marks, Question three: Attempt any two out of three questions, each of five marks.

Workload

Theory : 3 lectures per week per course.

Practical: 3 lecture periods per course per week per batch. All three lecture periods of the practicals shall be conducted in succession together on a single day.

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